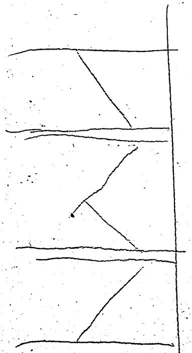
Notebook, N-00-08-31

This notebook is a continuation of N-00-08-21. It covers the period August-October 1900. All entries are by Edison. The book contains notes regarding alkaline storage battery experiments, including entries pertaining to a copper-cadmium cell. Scattered entries near the end of the book consist of drawings that appear to detail an ore milling operation. The front cover is marked "Sept 1900," and is labeled "Started Aug 31st 1900." The pages are unnumbered. Approximately 80 pages have been used.

Sept



266

6020
4535
5430

60)15985 (26
120
398
360
385
3

320
330
335
330
330
325
320
315
310
300
295
290
285
285
280
280
275
275
270
270
6020

265
265
260
255
255
250
245
240
235
230
225
215
205
195
185
175
150
125
280
280
4535

275
270
260
255
230
200
130
285
275
275
275
275
270
265
260
255
245
230
230
210
310
150
5430

Aug 31 1900

Storage Batty Expts

Continued —

74 = No 11 Cu reduced the oxide on it in tube with H low heat — on oxdz — 105.9 — .3 ampere Current This not been oxdzd afterward in flame — wt 59

gas strong at 11.10 — blue streak floated up to top —

Reversed to Redcg at 1112 am —

This seems strange

It probably means that

some if not all the particles had been made more dense by heat & that it requires flame Ox to CuO & reduction by Current to get it fine again —

or the Current density is too great, it not being so porous as the old ones 71 72 & 73 dont act that way but work all right with .13 Current density

I notice this plate Oxdz & Reduces all over & dont start at clamp

on reduction most gas comes off
Clamp - Color of plate
after reduction Crimson

On oxdg 11 26.

1136 - Blue streamers going
down very very weak -
in 1 minute seem to disappear
notice while the blue came
off there was a change
of color in the plate,
I just notice blue is going
to top instead of bottom
& in considerable amount

Commenced gas 1141 [illegible]

Revsd Redg 1133 am '3

gassing 1157 24 minutes

On oxdg at 12

I notice few bubbles keep coming off Electrode all time when oxdg — no blue yet 1212

at 1213 plate has a very green Color

Shaded part green beetle green

1215 green rapidly disappearing yellow taking its place.

1217 green gone

as plate oxdys all over this shows inside still Copper

Mem -

I note that with High density Current ~~on~~ blue appears only within a minute or 2 of gassing in Oxdtn + then disappears — This would look like to high density on Cop not yet oxdz'd.

12 18 blue coming out - stream down — 12 18½ Current off —

C on at 108 pm —

110 - no blue this would tend show wants fluid circulation to prevent blue on high densities of C —

112 blue starting seems to come off Edges — (high density)

(Moulding the plate burnished + hardened particles —)

Blue very considerable floats to top, then drops down — it isnt gas that

118

10

28

.59 metals

.246

Carries it up - no gas -
plate 116 very yellow & even all over -

118 plate turning greenish -
$118\frac{1}{4}$ gasing - slightly -
gasing a little more 119 pm
plate turning black -
120 pm gasing full - I will let it gas a while -

Theoretical for this plate
.246 amp Hour - gave .14

Revsd Reducg 125 pm -

This plate gases all over
both Ox & Redcg ?

gasing full 2 pm —
Revsd to Ox at 202 pm
2 33 —
gasing
31 min about ·15 amp hours
on Redg at 2:42
gasing 316 — 34 minutes
gasing full 317 — Reversed
Oxdz at [illegible] = 320 pm —
The liquid is getting quite blue
gasing 350 — ·15 amp H —
This is best it will
do I guess —
Hydrogen heat or mechanical
pressure increased
density too much

13.

2)27
13.5

4)23
5.8

17.8

.12

29

140

76 - Same as 74 but oxdyd flame
on Redug 1.40 pm .3 am Current.
I notice ~~that~~ this Electrode
reduces way down + not
progressively as others -
I mean at seams on Edges
way down to bottom
gasing 3 pm - 1 h 20 min.
.4 amp Hour -
On oxdz 303 pm -
gasing 328 - plate not
gasing - .125 amp Hour ~~[illegible]~~ Oxdz
Reversed ~~Redg~~ at 330 pm.
~~gasing 350~~
gasing 357 - .13.5 amp H Redug
358 Oxdz - Reduced to .14 amp
Current 4.22 pm as started
gasing - .12 amp on .3 Current

Over

at 446 - a small blue streamer
goes down
This is because its nearing gasing
& the density is very high on
the remaining unoxydized points -
gasing 4/47 - just one minute
after blue streak appeared
streak disappeared -
18.2 amphour
24.6 Theoretical -

Reversed 450 Redg .15 Current
about 73% This is
good Enough but I
dont like the streamer
of blue but perhaps it
has occurred in all the
test & I didnt notice it
it wouldnt amount to
anything in cup grid

Stopped gasing when Current reduced
Evidently liquid diffusion
~~gas~~ is necessary for high Current
density if Electrodes are
dense ~~so~~ its ok with
low density = with 76 plate
about .10 Current is about
right =

On oxdg 7 23 pm —
gas slightly 920 - 9 revsd
Reducing The moment the
gas ~~came~~
The Current has been 10.5 amp
This gives say .205 amp hour
Started Reducing 920 pm —
C .10.5

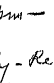
When I used the float Cop
just as it is & made plates
the Cu was partially oxdyd
& hence plate not so dense
after flame oxdtn it worked
at and .3 amp current but
there was some bluing still got
60 to 65 % Effcy

But when took same stuff &
reduced Ox from it by H at
very low temp it made it
more dense, cured just powder it
in fingers & all moulded it
harder & burnished surface &
probably stuff works — then
oxdyd it — It was then much
more dense than if the Cu
had not had its Ox off
hence lower density possible —

75 — same as 74 —
but only .14 Current
on oxdy 428 pm —

Its oxdy beautifully — Reddish
Crimson all over even —

Blue streaks very strong come
down at 515
at 531 Streamers stopped —
These streamers may be due
to burnished Copper hardened
thereby or a piece of hard lump
at 528 ~~streamers~~ ~~has~~ gone .14 amp hour
plate getting dark on one side
other side Crimson



536 blue streamers coming
again
537 going very slight

1.35

14
7
21

76 Continued
538 streamers gone —
plate gassing all over —
block all over — .165 amp hour —
Reversed Redeg 5 40 pm
.14 amp c

gassing 7 15
Towards the end when it
~~Started gassing~~ a
large amount of reddish
yellow floated out in
the liquid
think its particles detached
as they are only held by
pressure + not locked
as when flame oxidized

21

23.

It may be a Copper Hydride
hardly think it a precip
May be ? ? ni — ds on Friday
Until it does it =
Reversed to Oxdz 7.22 pm
1/0
Bad blue streamers persistent
starting at 9.10 & keeping
up till 9.45 going
9.45 = .2418 amp Hours
55
1

Liquid very blue

So Far the best copper is

Sulfate redcd by floated Zinc
dust = Then the Copper
floated = Washed by decantation
with little Sulphuric acid in
finally pure water till acid gone
then squeezed very dry in cloth
~~then~~ dried on steam bath,
Then powdered very fine in
agate Mortar, then reduced by
Hydrogen at a very low heat)
say 7 to 800 Fahr — Then
Moulded with Considerable
pressure then oxdized at
very dull red for one hour
This will give 82%

75 Continued

Evidently reduced Copper
~~[illegible]~~ worked direct is not
good — should be Oxdzd
before going in battery

End of 75

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76 Continued

Effcy after reducing & oxdz 2 or
3 times & no blue if density
of Current dont exceed .10
for the 1" long $\frac{1}{4}$" wide $\frac{1}{16}$ thick
held in clip — 20% NaOH —

Sept 5th 1900

Last few days have been experimenting on the Negative plate — instead of plating Zinc out of a Solution I have sought for a finely divided plate of a metal which would oxidize & reduce to the metal by the Current, Have prepared plates Reduced in Hydrogen in tube by heat of Molybdenum - Tungsten, Iron. Cerium, Cadmium — The Iron is promising but its pyrophoric Character makes it difficult

to manipulate surf plate is
too dense it forms the
soluble purple salt,
In all cases I use an
alkaline solution —
The Best metal so far is
Cadmium — CdO or CdO Hydroxide
is not soluble in KOH or
NaOH = By precipta the
Metal from the sulphate
with Zinc then washing
with alcohol & drying
& powdering by gentle
pressure Got a very

600 -
8
4800
2

1.10
8
880

finely divided powder which
presses into plates in the mould
beautifully = Have also
made plates of the Brown
Oxide & heated them —
They reduce with the
Current & oxdz OK but
the Metal plate seems to
be the best, Volts about
.4 — Have one plate
1/16 thick 1/4 wide 1" long
give 0.10 amphours
Am trying to oxidize a
plate of the finely divided

metal but its difficult
as the Oxdtn + melting
point are close together —
If this Cadmium works ok
it will be a good Solution
of the light Storage battery

I have tried a plate made
of ignited Zinc Oxide in
a weak alkaline Solution
this is promising but it
will have to be put in a
pocket as it tends to
disintegrate, the great

37

defect of Zinc is the
Solubility of even the
ignited Anhydrous Oxide in
the Solution —

Cell —

Metallic finely div pressed
plate Cd - not prev oxdzd
CuO plate = I am now reducing
Cd plate 1045 pm .10 —
Started gasing 1122 —
on dischg thro Res —
.78 milamp 1126 pm

OVER

Mem —

We have found way to Oxdz the plate of finely div'd Cd - put them in a metal Chamber on sand flame underneath, Thermom'r passes in chamber, Keep it 1 hour at 480 1/2 hour 550 one hour 600 — It does the biz fine — Dark Brown + tough plate —

pm —	Milamp
1126	78
1131	82
1135	82
1140	82
1145	82
1150	82
1155	82
12 midnight	82
1205 am	80
1210 "	79
1220 "	64
1225 "	42
1230	42

Opened Ckt

Weight of Cd plate not oxdz'd .68 gramme

about .08 of amp hour

5 - 75
5 77
5 78
15 78
10 78
27 - 72
4 50

375
385
390
1170
780
1940
2~~90~~
524060
1000
750
750

78
15
390
780
1170

71

.08

64
84
76

5 75

72
27
504
144
1944
112
16
128
160
1240
3200
6400
12.5

71 / 5240 (73.8
497
270
213
57

27

11

.73.8

73.8
8.1
8.1.9

738
11
738
738
8118

Sept 6th 1900

I now put cell charging at 8 am - .10 amp - gassing 850 - I let it gas for - 15 min - Copper also gassing -

On dischg at 905 - am

Time	Milamp	
905	180	
910	75 -	
915	77 -	
920 -	78	.44 valt now -
935	78	
945	76	.0819 amp Hour
1012	67	
1016	50	

60) 5254 (875
480
454
420
340
34

4	92
10	94
10	95
15	92
10	84
10	68

368
840
680
1380
950
1036
5254

92
15
460
92
1380

.1425

Redischarged

10 1135	152
1136	148
1136 ½	1.00
1136 3/4	.92 *
1137	92
1139	.92
1140	94
1150	95
12 noon	95
1205	93
1215	91
1220	87
1225	83

1230	76
1235	62

0875
amp hours

2 Light Color

On Redeq 1148 Elec gases the reason is probably that there is no Oxide on it

Current off 1210 on 12 53 pm

3 Brown Cd —

on Redeg 11 48 Elec dont gas
The reason it dont gas is
probably due to fact that it
is fairly oxdzd —
off 1210 on. 1253

4- Small piece of fairly
well oxdz Cd — Redcd
didnt put down time) of.
start → Redcd at 1255 pm -
Reoxd Oxdz 1255 .10

1 1/2

a Brownish plate -
Reduced - on discharg

time -	mils
320	.62
332	62
350	62
4pm.	62
410	61
	56
437	56
445	53
452	
5 -	50
512 -	28

Note the Cop was reduced put in a new oxdzd one

517	52
519	49
535	22

This is an plate made from Brown Ox. made by heating Cd Hydroxide — after plate made its brought gradually to Cherry red & then put — battery & reduced by Current which it does perfectly - all the way through - plate after reduction very dense dont see how any liquid Can get in —

I have in a Oxyd Copper & it dont start Current on reducing

Had to put Cu to the Hydgn pole & fully reduce it
.40 for 10 minutes —

610	30	Something wrong somewhere — I washed plate in washing — then put Cd & Cu plates in new Clamping — Dont Know what it is Except great density =
618	32	
635	32	
7	32	
710	32	
720	32	

over

Have just found the Bug its in the Copper by substituting a Current oxidized Copper went up to 80 mil amp at 720

It may not be the Cop — May be density of Cd after all —

720	.80
725	.75
off at 730 — on	
740	32

The black Copper was ~~oxydizable~~ reduced down about 1/4 " from clamps — The new one is metal inside & only Cu_2O & not CuO — Is it due to low Res — or Higher Heat of formation of CuO than Cu_2O — & thus increased the Volts —

Took Cu plate off 730 as it was deoxydized put it in another cell & oxydized it some — & put it back

Ox plate reduced - split open
Black Ox Cu plate -

822	90
825	98
830	65

Lightly pressed Cd powder plate - but strong enough to handle - New black Cop plate - Reduced Cu little by Current —

	pm	
On	855	85
	9.05	82

Notice that
plate gases
without Current
strongly - ⓘⓔ
the Ni holder
gives off nearly
all the gas -
must be local
action -
Oxdn of Cd-H
coming fm Ni

23
80
184
116

23 1840
2 152
13 650
22 1100
11 415
27 1080
5 300
13 559
116 6096 52
45 580
296
232
640
dam
1e

27
40
1080

13
50
650

11
45
55
44
495

22
50
1100

13
43
39

Opened the Circuit at 1253 am to test in morning of Soda gel — pores

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Cadmium Holder —
" plate fine stuff not strongly pressed —
Cu Black Ox plate reduced 1/8 inch from Clamps —

On		
1057	102	Cad plate & holder
1120	80	gassing quite strong I think it
1122	76	be due to impurities
1135	43	Zn is most likely
1157	51*	metal — Changed Cop Elec
1208	40	Put it Reday in Current
1235	60*	·10 for 20 seconds Went up from 40 to
1240	60	60 & kept there
1253	43	25 minutes so far

formation of water in pores of Copper plate probably increases resistance & thus accounts for fall Current from 75 to 40 - we tried Volts when at 40 milamperes & after it had been running one hour & it was .42 showing trouble is due to Res - plates have too great density giving poor porosity for Solution to Circulate –

200 milamph

68 2944
78 78)3254 (417
310
3124
1380
1780
566

160
150
31

.43 milamphours

417

.43

45)2.10 grams per a Hour

5
2/5

433
160

1000

417
78
3336
2919
32526 (542
60)325
300
252
240
12
) 14000 (206
13600
400

46
7
322

433
68
3464
2598
29444
28
44
112
112
1232

44
15
240
480
720

~~38~~
1 — 40
15 720
7 322
28 1232
7 280

350
10
68)2944 (.433
272
224
204
200

60)29444 (490
240
544
540
44

X 1

Cd by reduction in Current with weak solution Cd Sulphate - dendrites - packed quite hard in nickel pocket in grid - Black Cap - Oxdzd long heat - reduced - then reoxidized -

Current not touched this Cell -

416	10	.44 Valt
417	38	Weight .45 grammes of Cd in Cup -
418	40	
433	48	
440	46	25.2% Efficency
508	42	.490 Ma hours
515	40	taken
525	35	~~up to here 433 millamp hours~~
530 —	32	Volts .28
535 —	30	.542 Milla Hours

60)4053 (67 0''
360
453

2	– 104
5	– 265
8	416
10	520
7	364
8	416
15	690
10	400
65	3175
5	170
5	160
5	260
7	160
5	160
3	108
98	4053

4053

46
15
230
46
690

.53 mah

65)3175 (48
260
575
520
55

60)3175 (53

X 1 – Charged – till both poles gassed –

On at 620

620	26
622	52
627 –	53
635	52
645	52
652	52
700	52
715	46
725	40
730	34
off 732 to fix Contacts – on 750	36
755	32
off 8	

When I put it on first only went 15 millamp over charging does something – guess its gas as I shook it & it went to 50 mla

Its not gas for after 20 minutes I shook it & it went down & all kind ways bad Contact in Copper somewhere

(note – Bad contact Ni rivits as vibrating Cu Clamps Made Violent change)

4053
175
150
60) 4378 (.730
420
178

on 805	60	Reversed to charge 20 seconds
807	40	
812	32	
815	36	4053 m amp minutes
820	35	
825	30	

.73 Mil amp hour
34% Effcy
Cd as CdO
68% of Cd_2O -

on account of lack of surface in pocket it gases while charging even with .057 ampere

Red CdO —
pocket .750 mg wt

X1 Rechgd again —

935	52
950	55
10 —	57
1012	52
1025	48
1032	46

7000

X 2 –

Cd new mould – .8 grm not pressed hard but its ok

Cu is No 11 – oxdzd quick – not 1/2 done, but they are tough – I find ~~that~~ Cd has to be reduced as it must be greatly oxdzd its been on now 20 minutes .05 C —

It took One hour .07 C to reduce the plate which I ~~thought~~ was unoxdzd Cd —

1	110
4	376
5	430
2	192
3	279
5	465
5	46.5
10	900
10	820
10	700
5	260
1	72
8	568
15	1050
10	620
	7307

60) 7307 (10.5
60
307

15
78
105

On at		
1135	112	
1136	108	
1140	94	
✓1145	86	
✓1147	96*	
✓1150	93	
✓1155	93	
✓12 Midn	93	
✓1210	90	
✓1220	82	
✓1230	70	
✓1235	52	
1236*		
1237	72	
✓1245	71	
1 am	70	
1 10	62	
1 15	35	

I think there is no doubt but that Cd_2O is formed not CdO —

Took out some resistance

Notice that Cd Electrode is getting blisters due probably to oxide expanding hence it ought to be more porous if possible possibly it wouldn't blister if I had discharged it at a lower Current density.

* changed Copper to a new black one same as put in first
only count the above

I have put in a new Copper —

Oxidize the Cd with .07 Current tomorrow + Cook the 2 Coppers 2 hours in sand —

also make 2 doz more from Carbonate —

Oxdz still further

	mil amp	
833	70	On 833 still further oxidizing at .07 C changed to 50 at 840
834	going	
840	50	
850	50	at 940. only gaining 50% —
900	50	
915 940	52 53	

4125

75
55
375
375
4125
1300
5425

52
25
260
104
1300

60) 5425 (9.0
540
25

Started Reducing Cd plate at

Time	Mil A
945	55
11 00	55
11 25	52 *

a Brownish cloud pp came off the Copper plate. This may be Cd-plated on -

There was only a slight cloud no more appears

* gasing slightly

Only .09 Mil A Hours

Found plate all soft & ng

Cant use Cd plates must go in ~~[illegible]~~ Cups in grid & thoroughly reduced & repacked wet —

Mem-

a large pocket
packed with Electric redcd
Cd- washed immy after
production & put right in
grid & then in Soda process
immy C was put in
Redcg showing that it was
not oxdzd

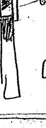
X3 - Is largesized pocket
packed with Electric reduced
Cd - alcoholed & air dried -
of course its all oxdzd &
pack it moderately hard
in Cup & reduce by
Current, this will make it
metal - then tamp it again
& reduce again a little
more then retamps it —

on
215- | 100

~~Mem No 11~~ ;

CuCarb reded plating
moulded new mould
900 - grams in Sand
Oxdy 4 hours -

I notice in reducing defects



black spot as if that area was out of Contact.

It looks as if Cd oxyd
got out Contact with Ni

No 1
Big grid — Cd by Current —
gave ~~266~~ 316 mil amp. Hours
packed in hard in sections -

No 2 same
gave 266 mil amp Hours
packed all at once by
finger & not so hard as
No 1 probably not sound
Cd in grid —

No 2 dischgd Completely —
I added a wide cup &
xtra grid & packed in
spongy Cop from Reading
Carb Cu by H in tube &
packed about same as
I pkd Cd in the other
grid, On Charging
at 925 pm 120 ma & 80
Copper gasing 1130 —
1140 — Cd not gasing I put
on discharging 94 ma
1140 pm —

2 u

2400
2070
1896

3750
3000
3500
9250

280
168

115
245
575

316 —
345
402

5 c

805
230
3162

115
3
345

#100 ton —

1%

20 — #5 lb

115
350
575
345
4025

2 50
1 25
62 1/2

2
4
8
16 ——— 31
32

125

115

16

12 45   55 ma —

Sept 18 1900

The Expmts so far show that the Cadmium Copper cell is a practical Commercial storage battery .44 volts with the active material under worst conditions 50% effcy as Cd_2O + Cu_2O —

There is as far as I can see no depreciation & the cell may be overcharged & also discharged to Zero without any defects showing — The current density on charging & dischg can be very great = Commercly the only thing against it is the small output of Cd in the world but undoubtedly there are many very Cadmious blendes not worked because of excess of Cd — large quantities could be obtained by redistilling Comml Zincs & from the Zinc people themselves I have been experimentg the last few days to

see if it is not possible to use
spongy Zinc in a Zinc Electrode —
with alkalis alone even when weak
the sponge dissolves — With Carbonates
& other alkaline salts the results
are bad but with Soda in which
there is dissolved a soda salt of an
acid whose Zinc Salt is insol
in the liquid works pretty good
The Volts are 65 @ 67 & the res low
it reverses all right — The Zinc Elec
is not attacked on account of the
presence of the spongy Zinc — the
Zn Hydroxide does not dissolve
on acct of the phosphoric acid
ditto Copper — But the Zinc & Copper
must be very fine — Ni Electrodes
used with the Cap —

1 1 1

14
4
56

600

4,800

Oct 2nd 1900

I find Magnesium is the best metal to plate Zinc on from Alkaline So — No local action — The Zinc is not solid but still adherent — it is good for 1 gramme Zinc per sq inch =

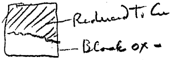
Oct 22 1900 -

Rufer figures 1st grid Cd Battery -
22 amphours for 100 grms Cd as Cd_2O -

Battery gives 2.52 Watt hours
External. Energy 310 grms -
100 Cd 66 Cu - External Res is 5.5 times
greater than internal -
500 lbs wld give say 1764 Watt hours
2.38 HP Hours external -

Phenomenon -

with a plate of Copper made from oxidzd $CuCO_3$ - + about 1/3 density of that from Cu itself when pressed + oxidzed - it reduces on $1\frac{1}{2}$ square inches OK with .6 amp - but when 3/5 is reduced it starts gassing



~~This shows this~~ whereas when only 1/6 was reduced it didn't gas with .6 amp - This thing has occurred twice in last few days + seems to show that when Cu surface is great to the Oxide there will be a point when it will gas !

on Reversing the oxdz- it soon gases
showing great dif bet Cu_2O + CuO
+ possibly some of Cu is out of
Contact — after oxdz to Cu_2O +
Reversing ·16 - it gases strong for
10 seconds + then in 3 more seconds
stops showing that when its
oxdzd to Cu_2O nearly all the
surface is oxdzd + when heavy
Current goes on the density
is too great for 1st few seconds

also notice that on 1st Red
of CuO to Cu Cu is bright then
after oxdn to Cu_2O + subsequent
oxdtn plate never gets bright
like at 1st its darkish in spots as of
some Cu_2O got out Contact

Results of these phenomenon -

is

1st There is apparently an enormous discrepancy in Capacity bet Redcg a plate from CuO as against Oxdz it again to Cu_2O as if it was Cu_4O — or Cu got out Contact

2nd When the Copper surface is 2/3 of the Oxide surface the density of the current must be greatly diminished otherwise it will gas —

33) 270 000 (8
264 000
6 000

8 HR

150 —

150
600 —
90 000

144
2
288 —

55 cents

9 44
60
33 — 264 00
237 600

44
67
308
264
2948

150 —
3

17
62
34

1 102
1054

384) 210 000 (546
192 0
[illegible]

.8

8 Kp [illegible]
[illegible]

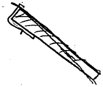
30
600
[illegible]
900
18 000
2 7

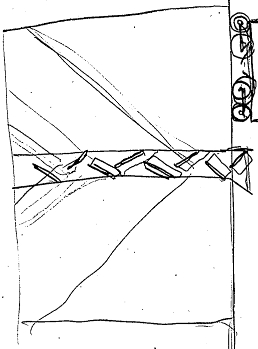
32
12
64
32
384

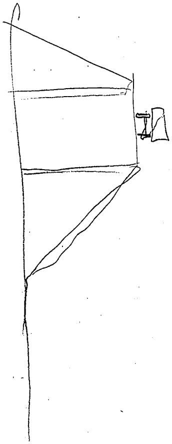
237 600

1980 000 (8
1900 800

6400







63

67
64
268
402
4288
421

67
70
4690

67
65
335
402

42—

246
75
1230
1722
18450

24 61
7
17220

81 44.

Lead - 88.8 20%

18.6

44.4
63

444
42
888
1776
18,648.

246
84
984
1968
20764

246
80
19680